JAPAN

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JIS H 8503 (1989) (English): Methods of wear resistance test for metallic coatings

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The citizens of a nation must honor the laws of the land.

Fukuzawa Yukichi

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JIS

JAPANESE INDUSTRIAL STANDARD

Methods of Wear Resistance Test for Metallic Coatings

JIS H 8503—1989

Translated and Published

by

Japanese Standards Association

In the event of any doubt arising,
the original Standard in Japanese is to be final authority.

UDC 620.193:620.178.16

JAPANESE INDUSTRIAL STANDARD J I S

Methods of Wear Resistance Test for Metallic Coatings H 8503-1989

1. Scope

This Japanese Industrial Standard specifies the methods of wear resistance test for electroplated coatings, hereinafter referred to as the "metallic coatings"(1).

Note (1) This Standard may be applied to chemical plating (electroless plating).

Remark: The units and numerical values given in { } in this Standard are based on the International System of Units (SI) and are appended for informative reference.

Further, the traditional units and numerical values accompanied by the SI units and converted values in { } shall be replaced by the units and the numerical values given in the Appendix on January 1, 1991.

2. Definitions

For the main terms used in this Standard the definitions in JIS H 0400 apply, and the rest of the terms shall be as follows:

2.1 wear Wear means a phenomenon in which materials are gradually exfoliated starting from the uppermost layers by mechanical action such as friction, polishing, etc.

2.2 friction ring The friction ring means an object of circular ring shape used in combination with the sample to wear out metallic coatings. The friction ring has a variety of one with abrasive paper glued to its circumference and one made of various other materials. It is also called wear ring.

2.3 DS DS herein is the abbreviation for double stroke, hence one reciprocation of friction is termed 1 DS.

2.4 wear mass The wear mass herein means the mass (mg) of sample peeled off in a wear test.

3. Classification of Testing Methods

(1) Sand-falling wear resistance test

(2) Jet wear resistance test

(3) Reciprocating motion wear resistance test

Applicable Standards:

JIS H 0400-Glossary of Terms Used in Electroplating

JIS K 6301-Physical Testing Methods for Vulcanized Rubber

JIS R 6111-Artificial Abrasives

JIS R 6252-Abrasive Papers

(4) Flat disk revolution wear resistance test (Taber's wear resistance test)

(5) Double ring driving wear resistance test (Amsler's wear resistance test)

4. Sample

4.1 Sampling The sample shall be taken from the significant surface of product or shall be the product itself. However, when testing the product is difficult to carry out, a substitute test piece may be used. In that case, the test piece shall be one representative of the product, and shall have the same substrate and treating conditions(2) of metallic coatings as the product.

4.2 Shape of Sample The shape of sample shall be respectively specified in each clause of testing method.

4.3 Treatment before Test The sample shall be wiped clean with soft cloth impregnated with a solvent(3) suited to the kind of stain.

Notes (2) The test piece herein shall be treated with the same bath and under the same condition as the product so that the equal effects of pretreatment and operating condition of metallic coatings may reflect on the test piece.

(3) The solvent herein means acetone, ethyl alcohol, ethyl ether, benzine, etc. and excludes the ones that will corrod the sample or form a protective film.

5. Conditioning of Sample

The conditioning of sample shall be carried out by generally leaving the sample as it is in a room kept at a temperature of 23 ± 2°C and a maximum relative humidity of 65% or in a thermohygrostat after cleaning its surface before the test, unless specially specified.

6. General Conditions of Test

The test shall, as a rule, be carried out in a room kept at a temperature of 23 ± 2°C and a maximum relative humidity of 65 % in the same way as in 5.

The wear resistance testing apparatus shall be correctly horizontally set on a solid laboratory table and stabilized so as not to generate abnormal movement due to vibration and the like accompanying the test.

7. Method for Sand-falling Wear Resistance Test

7.1 Summary This is a test in which abrasives are allowed fall from a specified height on to the surface of metallic coatings using an apparatus shown in Fig. 1 and the wear resistance of metallic coatings is examined.

7.2 Abrasives The abrasives to serve shall be #80 of silicon carbide abrasives C specified in JIS R 6111(4).

Note (4) Prior to use, the abrasives shall be sufficiently dried by heating (at about 110°C) and kept in a dessicator.

7.3 Test Apparatus The apparatus necessary for this test shall be composed of feed tank, funnel, duct, abrasive receiving case, etc. and shall meet the following conditions:

(1) Feed Tank The feed tank, though its size may be optional, shall be capable of regulating the falling amount of abrasives.

(2) Funnel The funnel shall be made of glass opening angle of 60°, an inner diameter of 70 mm in the head part, length of 50 mm in the leg part and inner diameter of 50 + 0.1 mm, and its lower inside and the inside of its leg shall be finished smooth. The regulation of falling amount of abrasives may be carried out by hanging a regulation bar in the centre of funnel, and by raising and loweirng it.

(3) Duct The duct shall be 970 mm in length and 20 mm in inner diameter, and the distance from the dropping hole to the surface of sample shall be adjusted to 1000 mm.

7.4 Sample The sample prepared in accordance with 4. shall be used and its standard dimensions shall be 50 mm x 40 mm.

7.5 Operation

7.5.1 Select the kind of abrasives according to the class of metallic coatings, put it into a feed tank and regulate the falling amount of abrasives by shifting the opening and closing board.

Allow the standard of the falling amount of abrasives per minute to be 320 ± 10 g in the case of #80.

7.5.2 After measuring([5]) the mass of sample with a chemical balance, fix the sample to the sample table so that the surface of the sample is 45° to the vertical direciton.

7.5.3 Actuate a stopwatch at the start of the testing and measure the time.

7.5.4 Continue the test until the mass of wear can be clearly measured or its substrate is exposed.

7.5.5 From the sample through with test, obtain the mass of sample in accordance with 7.5.2. Further, in the case of judging the exposure of substrate to be the end point, confirm the exact exposure.

Note ([5]) The measurement of mass of sample by a chemical balance may be omitted in the case of taking the exposure of substrate as the end point.

7.6 Judging Method

7.6.1 Method of Judging by Variaiton of Mass The wear resistance shall be calculated from the following formula:

$$WR=\frac{T}{w_1-w_2}$$

where, WR : wear resistance (s/mg)

w_1 : mass of sample before test (mg)

w_2 : mass of sample after test (mg)

T : test duration (s)

7.6.2 Method of Judging by Taking Exposure of Substrate as End Point To obtain the wear resistance, whether or not the substrate is exposed within a specified time shall be examined visually([6]).

Note ([6]) When the exposure of substrate is not clear in the substrate of iron and steel, it is recommended that a solution of copper sulfate be dripped onto the portion.

7.7 Record The following items shall be recorded:

(1) Testing method

(2) Class of sample

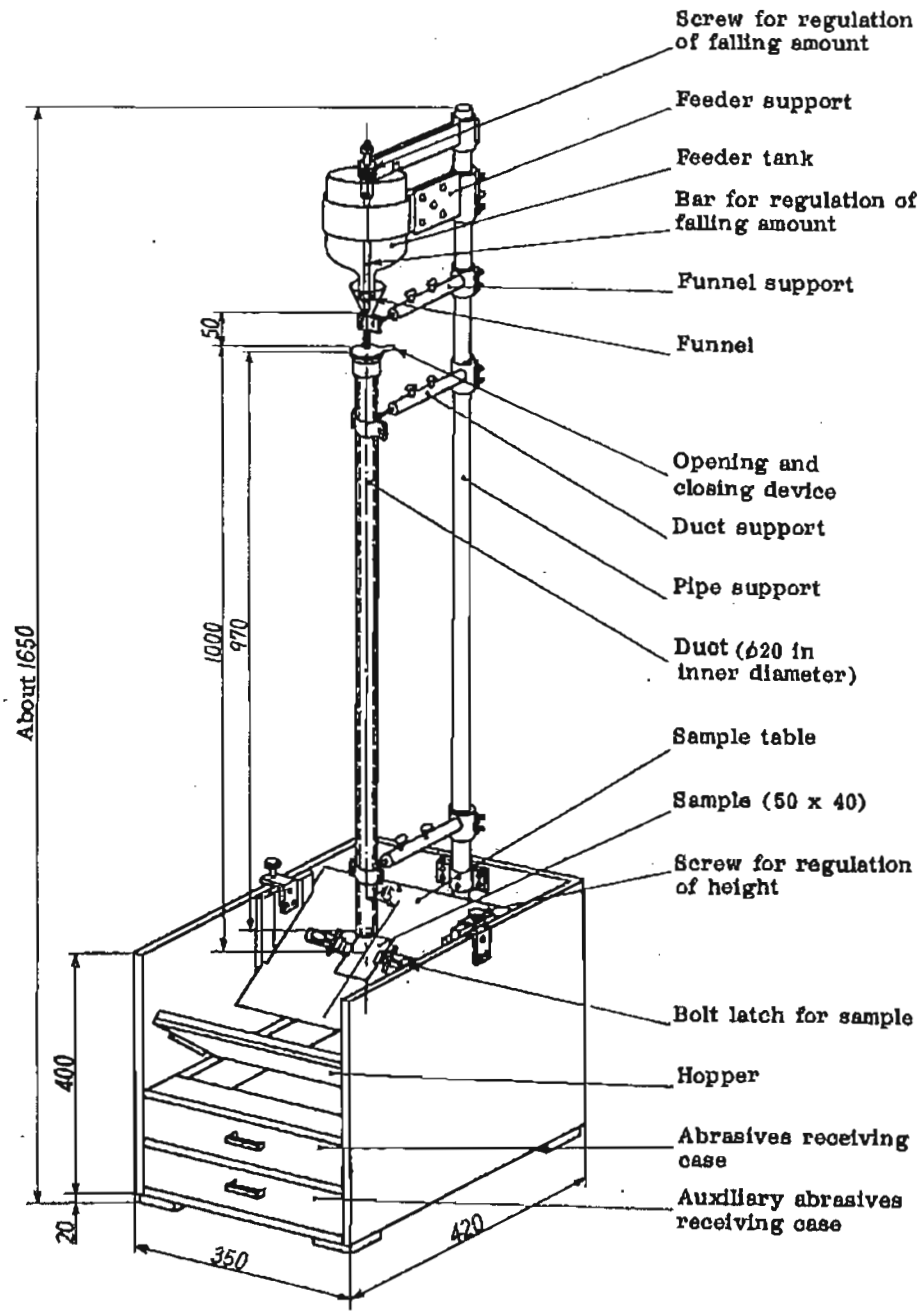
(3) Conditions for preparation of sample

(4) Class of abrasives

(5) Test duration

Fig. 1. Example of Apparatus for Sand-falling Wear Resistance Test

Unit: mm



8. Method for Jet Wear Resistance Test

8.1 Summary This test is to examine the wear resistance of metallic coatings by a method in which abrasives are injected onto the surface of sample as accelerated by compressed air with an apparatus shown in Fig. 2.

8.2 Abrasives The abrasives to serve shall be #100 of silicon carbide abrasives C specified in JIS R 6111([7]). Further, those once used shall not be reused.

Note ([7]) Prior to use, the abrasives shall be sufficiently dried by heating (at about 110°C) and kept in a desiccator.

8.3 Test Apparatus The apparatus necessary for this test shall be composed of a hopper for abrasives, a funnel, a sample table, a water column differential pressure gauge, a pressure control valve, an air compressor, etc. and shall meet the conditions given in Table 1.

Further, the natural falling amount (g) of abrasives shall be 23 ± 1 g per minute. Though the regulation of falling amount is carried out with an opening and closing board, it may be carried out by raising and lowering an adjusting bar hung in the center of funnel.

Further, to measure the falling amount, the amount having fallen during 5 to 10 min shall be converted to the amount (g) per minute. An example of the apparatus is given in Fig. 2.

Table 1. Conditions for Test Apparatus
(Applicable till the end of 1990)

Item	Conditions
Air feed	Not less than 1.5 kW air compressor
Pressure control valve	2 kgf/cm²{0.20 MPa} min.
Pressure gauge	2 kgf/cm²{0.20 MPa} min.
Pressure rubber tube	8.5 mm min. in inner diameter and 10.5 mm min. in outer diameter
Water column differential pressure gauge	1000 mm H_2O {9.8 kPa}

8.4 Sample The sample prepared in accordance with 4. shall be used, and its standard size shall be 50 mm x 40 mm.

8.5 Operation

8.5.1 Pur the abrasives into a hopper, open the opening and closing board and regulate the natural falling amount of abrasives to 23 ± 1 g per minute.

8.5.2 Fix the sample to a sample table to form 55 degrees to the vertical line (35 degrees to the surface of water).

8.5.3 Install the sample table so that the test surface of sample is about 10 mm directly below the nozzle.

8.5.4 Switch on the air compressor and regulate the air pressure between 408 and 1000 mm H_2O of water column differential pressure gauge with a pressure control valve according to the classification of metallic coatings.

8.5.5 Open the opening and closing board, inject the abrasives onto the sample and measure the time by actuating a stopwatch at the same time. Suitably regulate the variation of air presure of injection within the range of ± 5 mm water column with a water column differential pressure gauge.

Further, successively feed the abrasives into the hopper to minimize the variation of amount.

8.5.6 After the test, wipe the surface of sample clean with soft cloth and then judge the wear resistance.

8.6 Judging Method

8.6.1 Method of Judging by Taking Exposure of Substrate as End Point To obtain the wear resistance, whether or not the substrate is exposed within a specified test time shall be examined visually([6]).

8.6.2 Method of Judgment by Measuring Wear Depth of Test Part The wear resistance shall be calculated from the following formula by obtaining the maximum value of wear dpeth made by an injection of a definite time by means of a stylus type surface roughness tester or a split beam microscope([8]), etc.

$$WR=\frac{T}{t}$$

where, WR : wear resistance (s/μm)

T : test duration (s)

t : maximum value of wear depth (μm)

Note ([8]) When wear marks are small and deep, their measurement tends to be difficult.

8.7 Record The following items shall be recorded:

(1) Test method

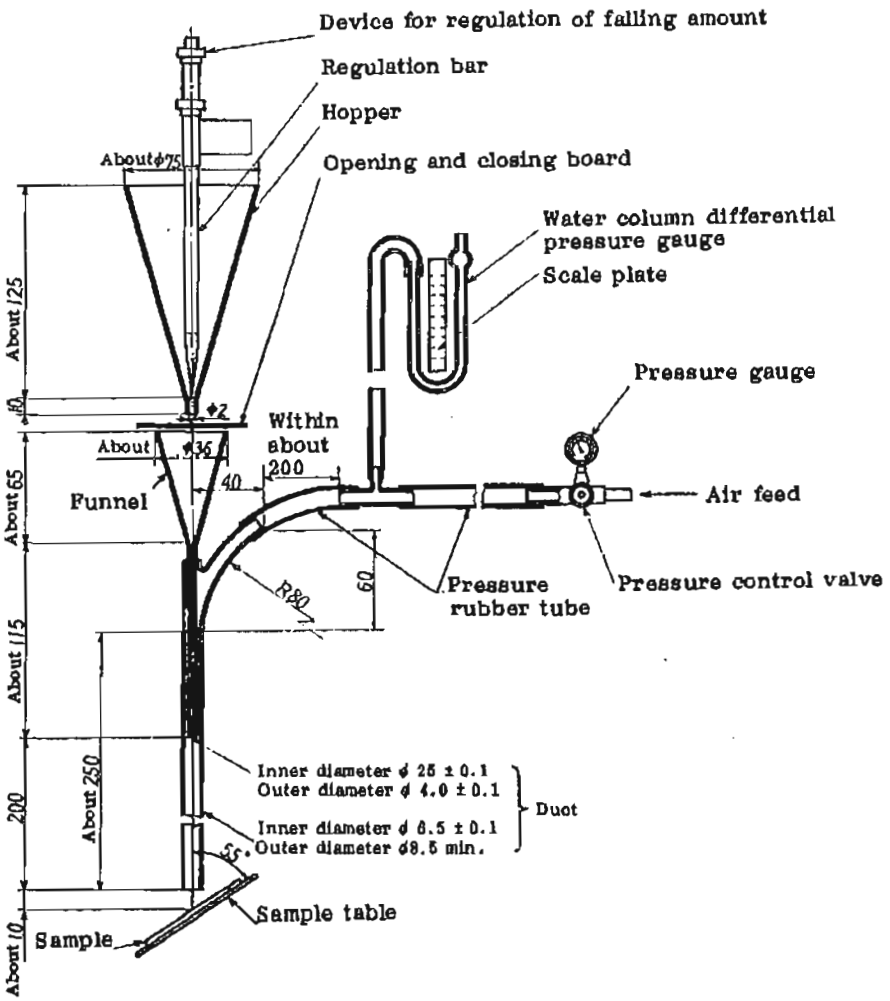
(2) Class of sample

(3) Conditions for preparation of sample

(4) Test duration

Fig. 2. Example of Apparatus for Jet Wear Resistance Test

Unit: mm



9. Method for Reciprocating Motion Wear Resistance Test

9.1 Summary This is a test to examine by means of an apparatus shown in Fig. 3, the wear resistance of metallic coatings against the friction load applied, through a reciprocation motion to the sample and the friction ring with abrasive paper stuck to it.

9.2 Abrasive Papers The abrasive papers to serve shall be #240 to #600 in particle size of CC or WA([9]) specified in JIS R 6252. Further, those papers([10]) shall be used after cut into 12 mm x 158 mm.

Notes ([9]) When increased wear mass is needed, it is recommended that an abrasive paper WA be used.

([10]) The abrasive papers to serve shall have adhesives applied on their back surface.

9.3 Test Apparatus The apparatus necessary for this test shall be composed of a sample fitting table, a friction ring, a reciprocating motion device, loading mechanism, an instrument for reading the number of reciprocation cycles, etc., and shall meet the following conditions:

(1) Sample Fitting Table The sample fitting table shall hold the sample securely and shall not move in the friction reciprocating motion to and from the friction ring. Further, powders fallen from the sample or the abrasive paper shall not stay on the test surface during the test([11]).

(2) Friction Ring The friction ring shall be 50.0 mm in diameter and 12 mm in width, and shall be provided with an automatic rotation device precisely rotating 0.9 degree for each reciprocation cycle so that the friction can be carried out always with new abrasive surface for each new cycle.

(3) Reciprocating Mechanism The reciprocating mechanism shall be capable of giving frictions by a stroke of 60 DS 30 mm per minute, and the test surface shall be uniformly frictionized.

(4) Loading Mechanism The loaidng device shall be capable of applying the maximum load of 3 kgf {29.4 N}([12]) between the friction ring and the sample. (Applicable till the end of 1990)

(5) Instrument for Reading Number of Rotational Frictions The instrument for reading the number of rotational frictions shall be capable of reading the number of reciprocation cycles between the friction ring and the sample. One interlocking with an automatic stopping device is preferable.

Notes ([11]) Power having fallen down may be removed with a suction device.

([12]) The loading device should preferably be one of variable load.

9.4 Sample The sample to serve shall be prepared in accordance with 4. and shall be 80 mm x 80 mm in standard dimensions and flat.

9.5 Test Conditons Although divergent performances and uses of metallic coatings make it impossible to formulate definite test conditions, recommendable test conditions are given in Table 2.

Table 2. Test Conditions
(Applicable till the end of 1990)

Classification	Test load kgf {N}	Particle size of abrasive paper #	For reference
1	1.5 to 2.5 {14.7 to 24.5}	240 to 320	Hard metallic coatings such as industrial chromium
2	1.5 max. {14.7 max.}	320 to 600	Other metallic coatings

9.6 Operation

9.6.1 Accurately and smoothly wind a specified abrasive paper along the circumferential circle of the friction ring so as to make exactly one revolution.

9.6.2 Fix the sample to the sample table stably and carry out, as a rule, preliminary wear([13]).

9.6.3 After cleaning the surface of sample with soft cloth, either measure the mass of sample with a chemical balance or measure the thickness of metallic coatings with a thickness measuring device([14]).

9.6.4 Carry out this wear test without changing the position of friction.

9.6.5 The abrasive paper shall not be reused. Therefore, allow 400 DS to be the limit for the abrasive paper and exchange the abrasive paper immediately after reaching this limit.

9.6.6 Continue the test until worn mass can be clearly measured or its substrate becomes exposed.

9.6.7 As to the sample through with the test([15]), obtain the mass of sample in accordance with the process of 9.6.3, or measure the thickness of metallic coatings worn away. Further, in the case of taking the exposure of substrate as the end point, confirm the presence of the exposed substrate.

Notes ([13]) Because the surface of sample is not necessarily uniform due to divergent substrates or conditions for metallic coating, the surface conditioning of sample shall be carried out. The recommended frequency is 50 to 100 DS.

([14]) A chemical balance capable of weighing to the nearest 0.1 mg shall be used. Further, the instrument for measuring thickness should preferably be of nondestructive type. However, in the case of taking exposure of substrate as the end point, this operation need not be carried out.

([15]) When there are a great number of cases in the test, measurement of mass should preferably made at the end of each cycle by allowing 400 DS to be a unit cycle and the worn condition ascertained.

9.7 Judging Method

9.7.1 Judging Method by Change of Mass or Change of Thickness of Metallic Coatings The wear resistance shall be calculated from the following formula:

$$WR=\frac{N}{w_1-w_2} \quad \text{or} \quad WR=\frac{N}{t_1-t_2}$$

where, WR : wear resistance (DS/mg) or (DS/μm)

w_1 : mass of sample after preliminary wear (mg)

w_2 : mass of sample after test (mg)([16])

t_1 : thickness of metallic coatings of sample after preliminary wear (μm)

t_2 : thickness of metallic coatings of sample after test (μm)

N : number of DS of test

9.7.2 Method of Judging by Taking Exposure of Substrate as End Point To obtain the wear resistance, whether or not the substrate is exposed by the frictions within the specified frequency shall be examined visually([16]). However, the portion excessively worn away by the rotation of friction ring (refer to Fig. 4) shall be omitted.

Note ([16]) To convert the worn mass obtained by weighing to thickness, due consideration shall be given to abnormally worn positions.

9.8 Record The following items shall be recorded:

(1) Test method

(2) Class of sample

(3) Conditions for preparation of sample

(4) Class and particle size of abrasive paper used

(5) Test load

(6) Number of frictions

Fig. 3. Example of Apparatus for Reciprocating Motion Wear Resistance Test

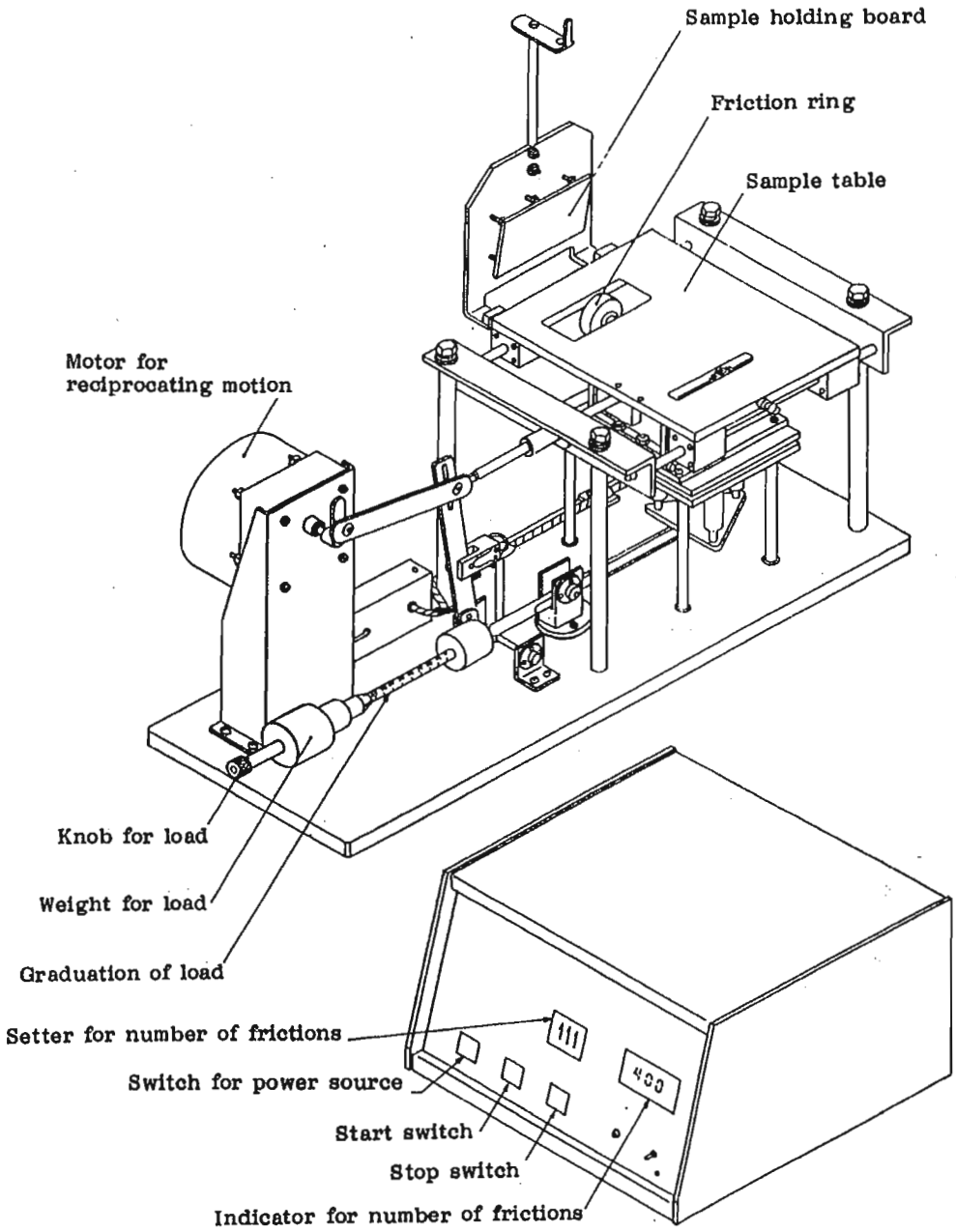
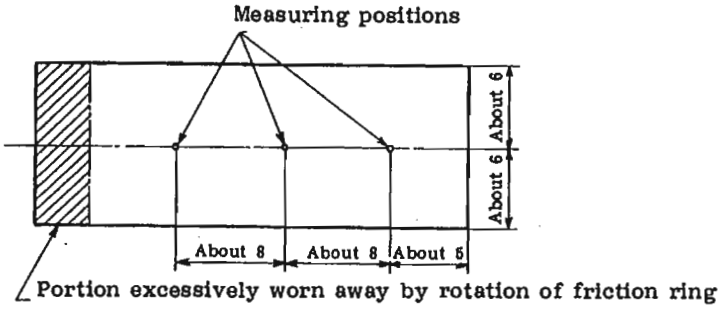


Fig. 4. Positions for Measurement of Thickness Using Thickness Measuring Instrument

Unit: mm



10. Method for flat Disk Revolution Wear Resistance Test (Method for Taber's Wear Resistance Test)

10.1 Summary This is a test to examine the wear resistance of metallic coatings by a test method in which an apparatus as given in Fig. 5 is used and the sample is attached to a rotary horizontal disk and frictions of a specified load are applied to it by a pair offriction rings with abrasive papers stuck to them.

10.2 Abrasive Papers The abrasive papers to serve shall be those of #240 to #600 particle sizes of CC or WA([9]) specified in JIS R 6252([10]).

10.3 Test Apparatus The apparatus necessary for this test shall be composed of the main body of driving part, a rotating disk and a sample fixing frame, an instrument for reading of rotation number, friction rings, deadweight and its attaching arms, a device for sucking worn powders, etc., and its mechanism shall be as given in Fig. 5.

10.3.1 Construction Details of Test Apparatus The construction details of test apparatus shall be as specified in Table 3.

Table 3. Construction of Individual Parts of Test Apparatus

Individual parts		Specification
Arm (for attachment of friction ring and dead-weight)		Shall be so constructed as to balance when 250 g weight is loaded on the other end of arm with no deadweight and no friction ring attached to the arm.
Shaft to attach friction ring		Shall have an outside diameter of ϕ $15.87^{0}_{-0.03}$ mm and shall show no axial play or rotary diflection.
Rotating disk	Rotating speed	60 ± 2 rpm
	Rotating deflection	Vertical deflection of its upper surface on its outer periphery shall not exceed 0.08 mm.
Deadweight		Mass tolerances shall be ± 0.1 % of its nominal mass.
Instrument for reading rotation number		Shall be capable of integrally indicating rotation numers up to 9999, be accurately actuated and its automatic stopper mechanism reliable.
Driving of apparatus		Shall be driven smoothly and accurately, each mass being regulated to 1000 g, with a rubber sheet instead of the sample attached to the rotary disk and with a rubber ring on top of it.
Device for sucking worn powder	Suction port	Inner diameter ϕ 8 ± 0.1 mm
	Airflow	The airflow shall be 0.5 ± 0.1 m^3/min for the device for suction with the clearance between the sample and the suction port 3 mm.

10.3.2 Relation between Rotary Disk and Friction Ring In the relation between the rotary disk and the friction ring, a_1, a_2 and D shall be as follows in accordance with Fig. 6.

$a_1 = a_2 = 39.4 \pm 0.3$ mm

$D = 19.0 \pm 0.2$ mm

10.3.3 Rubber Ring for Friction Ring

(1) The shape, dimensions and construction of rubber ring shall be as given in Fig. 7.

(2) Materials of individual parts given in Fig. 7 shall be as follows:

A: Rubber of hardness 50 to 60 as specified in JIS K 6301
B: Hard rubber

(3) When the rubber ring is attached to the shaft for attaching friction ring there shall be fit accurate with no play and no generation of deflection of surface. The permissible deflection of surface shall be ± 0.05 mm as measured with a dial gauge.

10.4 Sample The sample to serve shall be prepared in accordance with 4. and its standard shape shall be of a circular one 120 mm in diameter with a hole about 6 mm in diameter bored at its center.

10.5 Test Conditions Though fixed test conditions can not be established because of divergent performances of metallic coatings and their uses, recommendable conditions are given in Tabel 4.

Table 4. Test Conditions
(Applicable till the end of 1990)

Classification	Test load kgf {N}	Particle size of abrasive paper #	For reference
1	1.0 {9.8}	240 to 320	Hard metallic coatings such as industrial chromium
2	0.5 {4.9}	320 to 600	Other metallic coatings

DOES OUR MACHINE HAVE ABRASIVE PAPER?

10.6 Operation

10.6.1 Preparation of Friction Ring Accurately and smoothly wind a new unit set of 2 sheets of specified abrasive papers along the circumferences of 2 rubber rings for test so as to make one revolution, allow the rubber ring to be friction rings for test and accurately attach them to specified positions of respective shafts for attaching friction ring in accordance with 10.3.3 (3).

10.6.2 Attachment of Sample After measuring([14]) the mass of sample prepared in accordance with 4. with a chemical balance, accurately fix it to the position in the rotary disk for attaching sample with the test surface facing up. In the test, when the sample can not be kept horizontal because of a thin sheet, accurately fix it with a frame for fixing sample.

10.6.3 Make a test load by attaching deadweight to the shaft for attaching friction ring and lower and put it on the test surface.

Prepare a device for suction of worn powders and set its suction port by adjusting it at 3 ± 0.2 mm above the test surface. Set the scale graduation of suction device so that the airflow sucked by a suction device reaches a specified value given in Table 3 and actuate it.

After confirming that the relative positions of the sample and the friction ring are kept at specified positions of 3.2, start the operation of apparatus for wear test. Allow the rotation speed of rotary disk to be 60 ± 2 rpm.

Replace abrasive papers used for the test with new ones at the end of each 100 rotations.

10.6.4 Continnue the test until the worn mass is clearly measured or the substrate is exposed.

10.7 Judging Method

10.7.1 Method for Judgment by Variation of Mass The wear resistance shall be calcualted from the following formula:

$$WR=\frac{N}{w_1-w_2}$$

where, WR : wear resistance (time/mg)

w_1 : mass of sample before test (mg)

w_2 : mass of sample after test (mg)

N : number of rotations (times)

10.7.2 Method for Judging by Taking Exposure of Substrate as End Point To obtain the wear resistance, visually examine whether or not the substrate is exposed by the frictions within the specified number of rotations([6]).

10.8 Record The following items shall be recorded:

(1) Test method

(2) Class of sample

(3) Conditions for preparation of sample

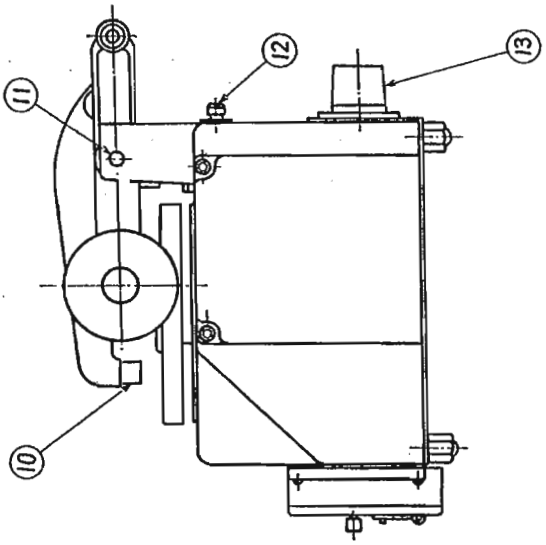
(4) Class and particle size of abrasive papers used

(5) Test load

(6) Number of rotations

(7) Other items considered necessary

No.	Remarks
1	Friction ring
2	Shaft for attaching friction ring
3	Knob for fastening friction ring
4	Deadweight
5	Arm for attaching friction ring and deadweight
6	Frame for fixing sample
7	Rotary disk
8	Knob for fastening sample
9	Washer
10	Device for sucking worn powder (suction port)
11	Fulcrum of arm
12	Knob for raising and lowering suction device
13	Connection port of device for sucking worn powder
14	Driving switch
15	Cycle counter
16	Airflow regulator



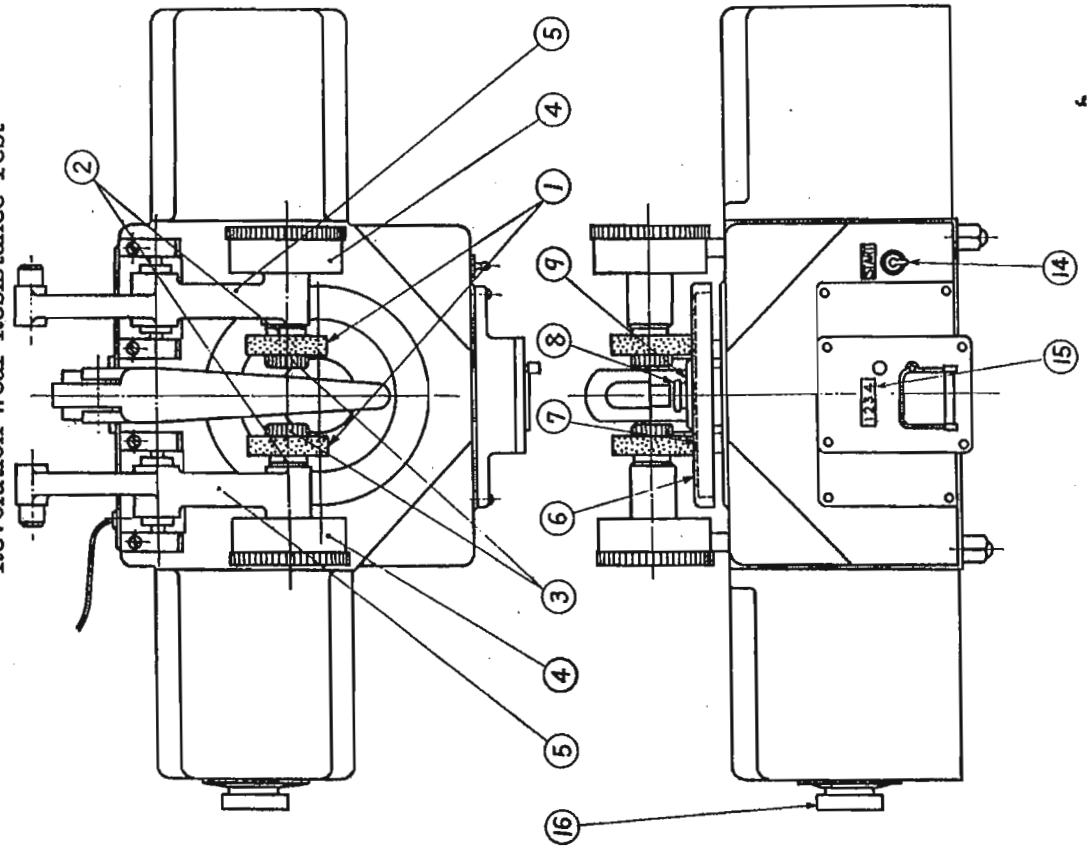


Fig. 5. Example of Apparatus for Flat Disk Revolution Wear Resistance Test

Fig. 6

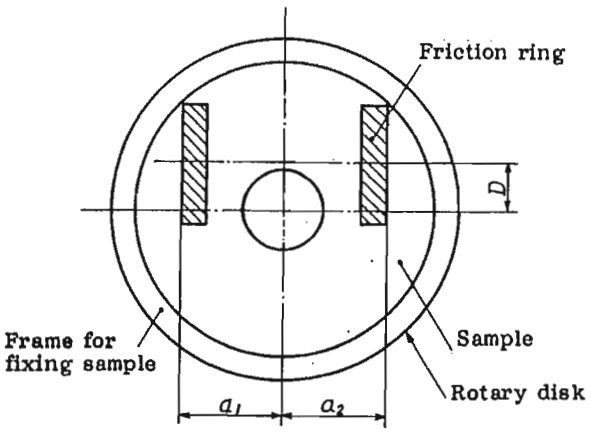
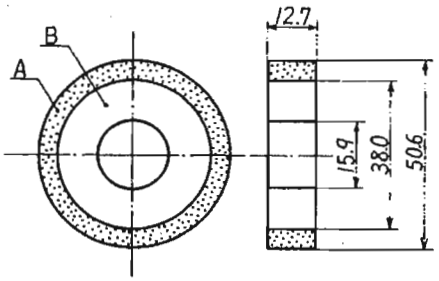


Fig. 7

Unit: mm



11. Method for Double Ring Driving Wear Resistance Test (Method for Amsler's Wear Resistance Test)

11.1 Summary The wear resistance of metallic coatings is examined by the test method in which load is applied between the sample and the friction ring with an apparatus as given in Fig. 8. thereby causing a rolling friction or sliding friction with 10 % slip factor under dry or wet condition.

11.2 Test Apparatus The apparatus necessary for this test shall be composed of a shaft attaching sample, a driven shaft, a rotation device, a lubricating oil dripper, a friction movement setting device, a loading device, an instrument for reading the number of rotational frictions, etc., and shall meet the following conditions:

(1) Shaft for Attaching Sample and Driven Shaft The shaft for attaching sample and the driven shaft shall be kept in parallel and horizontal and shall securely hold the sample and the friction ring.

(2) Sample Rotation Device The sample rotation device shall be so constructed that the number of rotations of the shaft for attaching sample is always constant (200 per minute) and the rotary direction of sample is in the direction where worn powder falls down on the friction surface. Further, the number of rotations shall not fluctuate due to the addition of load.

(3) Lubricating Oil Dripper The lubricating oil dripper is used for a wet test and shall be capable of dripping a fixed amount of lubricating oil.

(4) Friction Movement Setting Mechanism

(4.1) Rolling Friction For the rolling friction the number of rotations of driven shaft shall be adjusted to 180 per minute by a combination of small and large toothed wheels attached to the driving and driven shafts. Further, the shaft for attaching sample shall have the same rotary direction and the same number of rotations as those of the driving shaft.

(4.2) Sliding Friction For the sliding friction, the small toothed wheel of driving shaft shall be easily detached, a rotation stopper attached to the driven shaft and the driven shaft fixed fast.

(5) Loading Device The loading device shall be capable of arbitrarily applying load from 100 gf {0.98 N} to 30 kgf {294 N} between the sample and the friction ring. (Applicable till the end of 1990)

(6) Instrument for Reading Number of Rotational Frictions The instrument shall clearly read the number of rotations of the shaft for attaching sample.

11.3 Sample and Friction Ring The sample prepared in accordance with 4. shall be used, its standard dimensions being ϕ40 mm in outer diameter, ϕ16 mm in inner diameter and 10 mm in thickness.

Materials of the friction ring shall be suitably selected in due consideration of use surroundings of the products.

11.4 Test Conditions Though definite test conditions can not be established because of the divergent performances and uses of metallic coatings, recommendable conditions are given in Table 5.

Table 5. Test Loads
(Applicable till the end of 1990)

Classification	Lubricant		For reference
	Without	With	
1	100 to 300 of {0.98 to 2.94 N}	—	Gold plating
2	200 gf to 2 kgf {1.96 to 19.6 N}	2 to 15 kgf {19.6 to 147 N}	Silver plating
3	2 to 10 kgf {19.6 to 98 N}	5 to 20 kgf {49 to 196 N}	Hard metallic coatings such as industrial chromium and the like.

11.5 Operation

11.5.1 Measure either the mass of sample with a chemical balance or the thickness of metallic coatings with an instrument for measuring thickness.

11.5.2 Fix the sample to the shaft for attaching sample and the friction ring to the driven shaft.

11.5.3 In the case of the rolling wear test, establish the rolling friction conditions provided with 10 % slip factor between the sample and the friction ring by attaching a small toothed wheel to the shaft for attaching sample, a large toothed wheel to the driven shaft and setting the ratio of the number of rotations of the shaft for attaching sample and the driven shaft for 200 to 180.

11.5.4 In the case of the sliding wear test, establish the sliding friction conditions without attaching a small toothed wheel to the driving shaft but with a rotation stopper attached to the driven shaft.

11.5.5 In the case of using lubricating oil, established the dripping speed for the lubricating oil dripper.

Further, in the case of using grease, apply grease to the surface of sample.

11.5.6 Continue the test until the mass of worn metallic coatings or the thickness of metallic coatings can be clearly measured.

11.5.7 After the test, wipe the surface of sample clean with soft cloth impregnated with a suitable solvent([3]) when lubricant is applied to the surface of sample, and simply wipe clean with soft cloth when lubricant is not used. Thereafter, measure the mass of worn metallic coatings or the thickness of metallic coatings.

11.6 Judging Method The wear resistance shall be calculated from the following formula by the gravimetric method or the method for measuring thickness,

$$WR=\frac{N}{w_1-w_2} \quad \text{or} \quad WR=\frac{N}{t_1-t_2}$$

where WR : wear resistance (times/mg) or (times/μm([17])

w_1 : mass of sample before test (mg)

w_2 : mass of sample after test (mg)

t_1 : thickness of metallic coatings of sample before test (μm)

t_2 : thickness of metallic coatings of sample after test (μm)

N : number of rotational frictions([16]) (times)

Note ([17]) In the case of obtaining the friction distance from the number of rotational frictions, calculate from the following formula:

In the case of 10 % rolling friction

$$l=0.04\times\pi\times N\times 0.1$$

In the case of sliding friction with interlocked shaft fixed

$$l=0.04\times\pi\times N$$

where l : friction distance (m)

0.04 : diameter of sample (m)

0.1 : slip factor

N : number of rotational rotations (times)

11.7 Record The following items shall be recorded:

(1) Test method

(2) Class and conditions of metallic coatings

(3) Surface roughness

(4) Test load

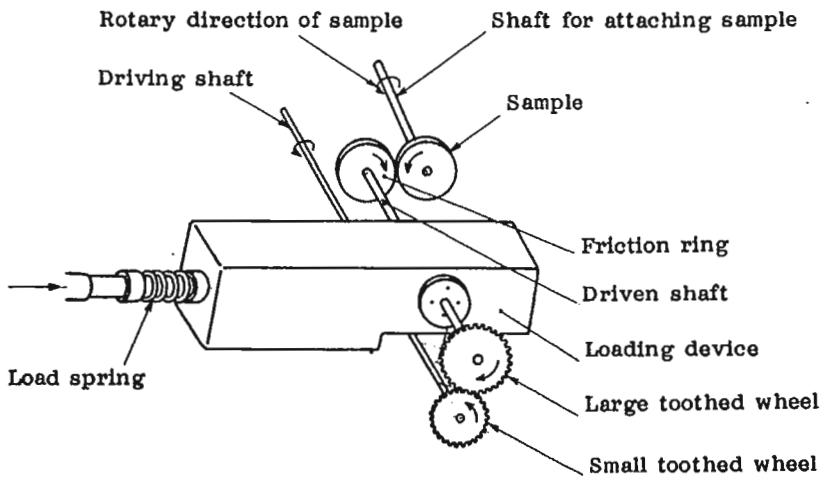
(5) Use or nonuse of lubricating oil

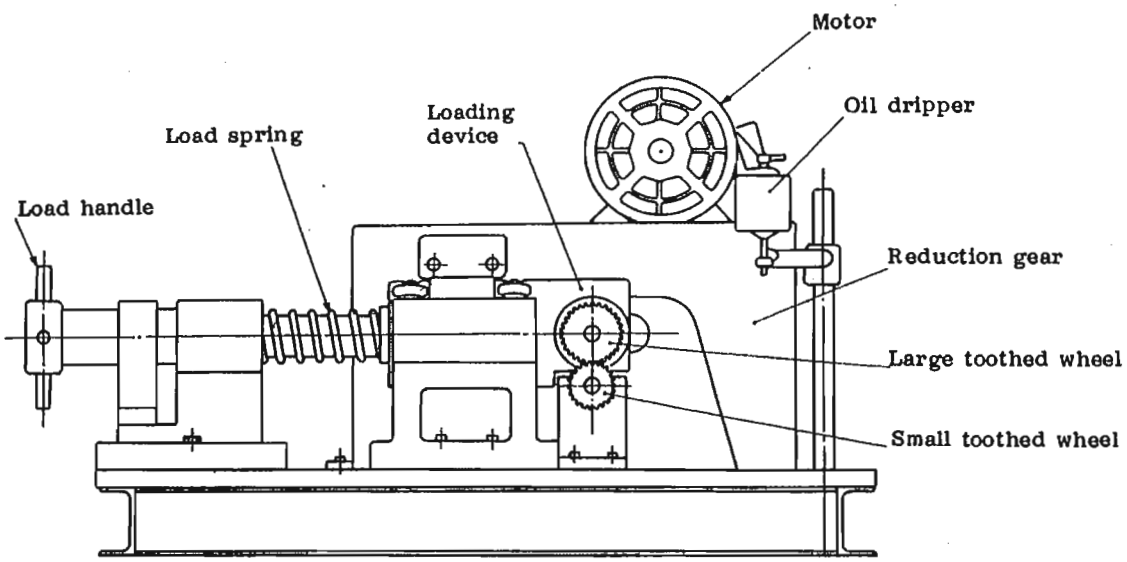
(6) Class and amount of lubricant

(7) Number of rotations or distance of friction

(8) Materials and surface conditions of friction ring

Fig. 8. Example of Apparatus for Double Ring Driving Wear Resistance Test





Appendix

The load values by traditional units specified in 8.3 of the main text of of this Standard and the test load values by traditional units specified in 9.3 (4), 9.5, 10.5, 11.2 (5) and 11.4 shall be replaced by the specified values based on the SI units on January 1, 1991.

8.3 Test Apparatus The apparatus necessary for this test shall be composed of a hopper for abrasives, a funnel, a sample table, a water column differential pressure gauge, a pressure control valve, an air compressor, etc. and shall meet the conditions given in Appendix Table 1.

Further, the natural falling amount (g) of abrasives shall be 23 ± 1 g per minute. Though the regulation of falling amount is carried out with an opening and closing board, it may be carried out by raising and lowering an adjusting bar hung in the center of funnel.

Further, to measure the falling amount, the amount having fallen during 5 to 10 min shall be converted to the amount (g) per minute. An example of the apparatus is given in Fig. 2.

Appendix Table 1. Conditions for Test Apparatus
(Applicable on and after Jan. 1, 1991)

Item	Conditions
Air feed	Not less than 1.5 kW air compressor
Pressure control valve	0.20 MPa min.
Pressure gauge	0.20 MPa min.
Pressure rubber tube	8.5 mm min. in inner diameter and 10.5 mm min. in outer diameter
Water column differential pressure gauge	9.8 kPa

9.3 (4) Loading Mechanism The loading device shall be capable of applying the maximum load of 30 N(^{12}) between the friction ring and the sample. (Applicable till the end of 1990)

9.5 Test Conditions Although divergent performances and uses of metallic coatings make it impossible to formulate definite test conditions, recommendable test conditions are given in Appendix Table 2.

Appendix Table 2. Test Conditions
(Applicable on and after Jan. 1, 1991)

Classification	Test load N	Particle size of abrasive paper #	For reference
1	15 to 25	240 to 320	Hard metallic coatings such as industrial chromium
2	15 max.	320 to 600	Other metallic coatings

10.5 Test Conditions Though fixed test conditions can not be established because of divergent performances of metallic coatings and their uses, recommendable conditions are given in Appendix Table 3.

Appendix Table 3. Test Conditions
(Applicable on and after Jan. 1, 1991)

Classification	Test load N	Particle size of abrasive paper #	For reference
1	10	240 to 320	Hard metallic coatings such as industrial chromium
2	5	320 to 600	Other metallic coatings

11.2 (5) Loading Device The loading device shall be capable of arbitrarily applying load from 1 N to 300 N the sample and the friction ring. (Applicable on and after Jan. 1, 1991)

11.4 Test Conditions Though definite test conditions can not be established because of the divergent performances and uses of metallic coatings, recommendable conditions are given in Appendix Table 4.

Appendix Table 4. Test Loads
(Applicable on and after Jan. 1, 1991)

Unit: N

Classification	Lubricant		For reference
	Without	With	
1	1 to 3	–	Gold plating
2	2 to 20	20 to 150	Silver plating
3	20 to 100	50 to 200	Hard metallic coatings such as industrial chromium and the like

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